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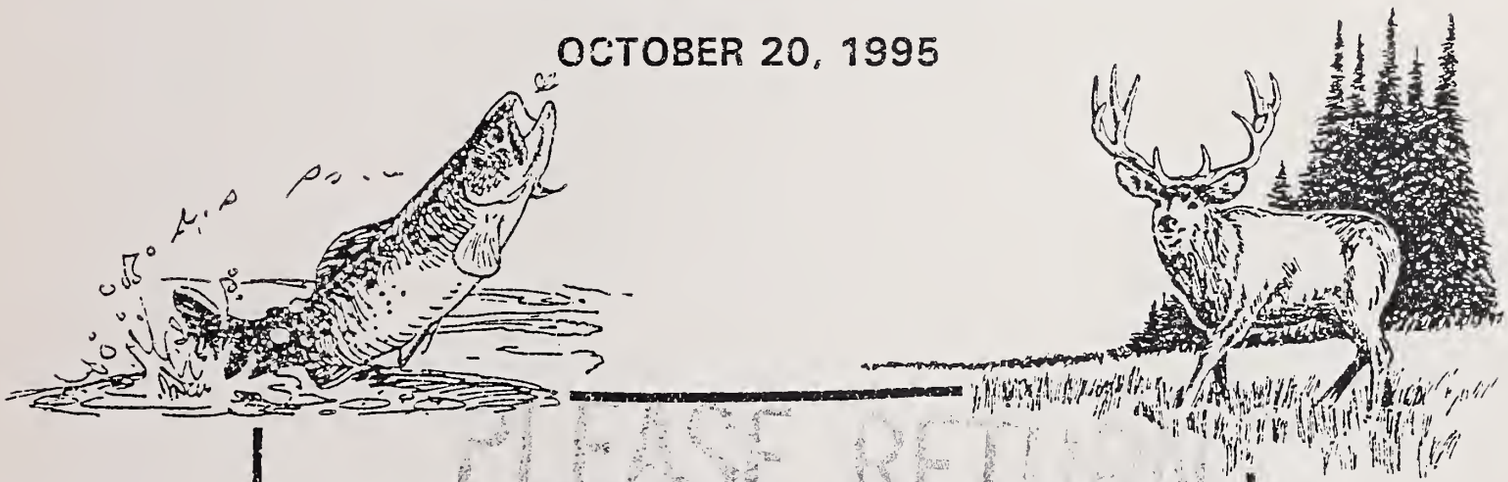
1995 Response to
ARCO's reports
concerning the
State of Montana's
injury assessment

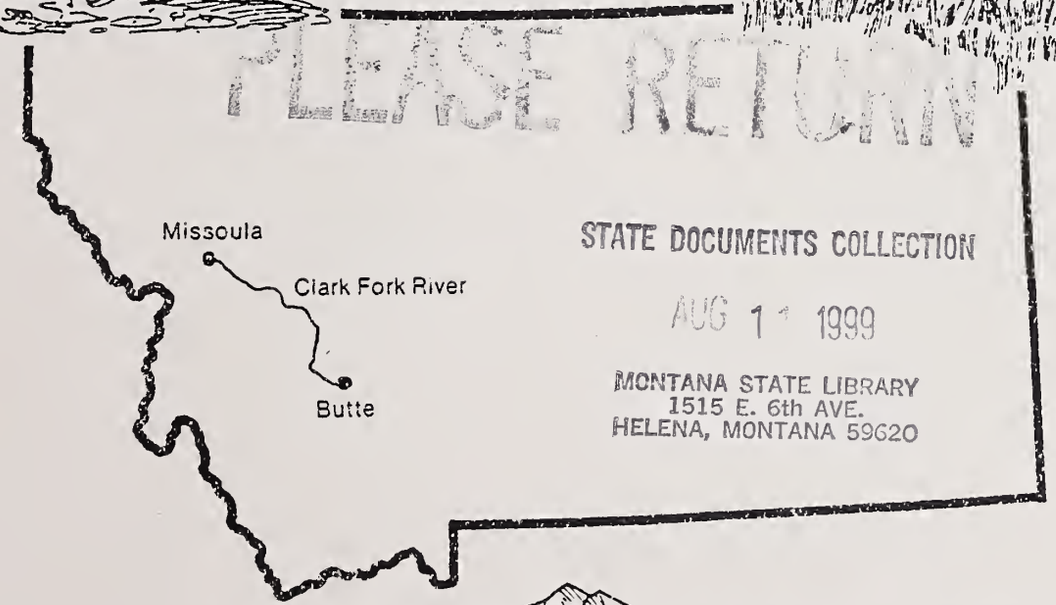
STATE OF MONTANA
RESOURCE DAMAGE PROGRAM

RESPONSE TO ARCO'S REPORTS CONCERNING THE STATE OF MONTANA'S INJURY ASSESSMENT FOR THE UPPER CLARK FORK RIVER BASIN

PREPARED BY:
RICHARD C. KONOPACKY Ph.D.

OCTOBER 20, 1995





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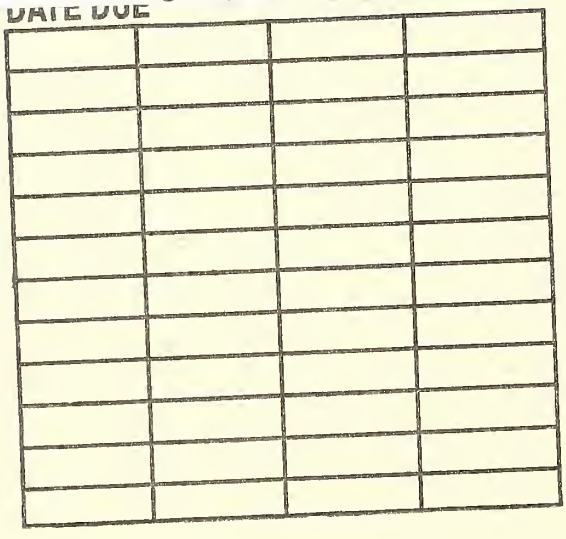

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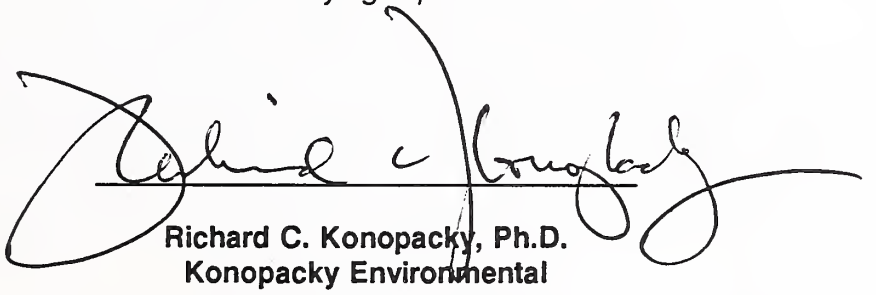
RESPONSE TO ARCO'S REPORTS CONCERNING THE STATE OF MONTANA'S INJURY ASSESSMENT FOR THE UPPER CLARK FORK RIVER BASIN

Prepared by

Richard C. Konopacky, Ph.D.

Testifying Expert:



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October 2, 1995

Use of the HQI Model to Estimate Salmonid Standing Crop in the Clark Fork River

by

R.C. Konopacky

In materials prepared for ARCO, Reiser (1995) used the Habitat Quality Index (HQI) Model to predict the standing crop or biomass of salmonids in the Clark Fork River (CFR) based on habitat measurements at study sites along the river. Although other similar study sites existed in Silver Bow Creek and possibly other tributaries to the CFR, Reiser (1995) did not collect or did not present HQI calculations for any non-CFR sites. Reiser (1995) used the HQI data and subsequently calculated products to support opinions counter to the State of Montana. His opinions dealt with salmonid standing crops in various reaches of the river, differences in habitat quality among various reaches of the river, and variables that were more important or "drove" the HQI-derived relationship between habitat quality and salmonid standing crop. This memorandum will discuss or show that the HQI model: 1) was not an accurate or precise tool for predicting the standing crop or quality/quantity of habitat in the Clark Fork River basin and was, therefore, inappropriate as used by Reiser (1995); 2) was used incorrectly by Reiser (1995) because of errors in data collection, failure to use available data, and failure to calculate/present all variables in the model (regardless of the inappropriateness of model use); and 3) was used by Reiser (1995) in preference to other classification approaches developed for stream systems.

What is the HQI Model?

An explanation of the HQI Model is necessary to understand the inappropriate and inconsistent use of the model by Reiser (1995) in the CFR. The Habitat Quality Index or HQI model was developed by Binns (1982) of the Wyoming Game and Fish Department (WGFD) in the late 1970s. The WGFD, in response to the Water Resources Planning Act (i.e., Public Law 89-80), needed a standard method to quantify habitat in Wyoming trout streams. In the first of the two-step development process, Binns (1979) used habitat measurements from 20 stream reaches from throughout Wyoming to develop HQI Model I. In Model I, trout standing crop, in pounds/acre, was equal to the sum of "rated" individual or "primary limiting" variables (i.e., late summer stream flow, annual stream flow variation, and maximum summer stream temperature) and the product (i.e., P-factor) of seven other rated variables (i.e., nitrate nitrogen, fish food abundance, fish food diversity, cover, eroding stream banks, water velocity, and stream width).

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Binns (1982) rated all variables used in Model I and in Model II through a subjective approach that was inconsistent and without explanation relative to rating ranges per variable (Figure 1). In addition to the unexplained relationships between ratings and related data ranges, the Wyoming Game and Fish Department or WGFD (Pers. comm., September 21, 1995) stated that both HQI models were developed for trout streams with the assumption that water quality was adequate to support trout populations (i.e., a potentially lethal unmeasured variable was not present in the stream). The WGFD also stated that use of the HQI in a stream with a large amount of unnatural controls on flow (e.g., channelization) or a heavy metals problem (e.g., mercury) would confound the ability of the model to predict salmonid standing crop. The WGFD suggested that, in such cases, the model required "customization" or the integration of an additional variable to account for the confounding variable (i.e., standing crop of fish and/or fish food in a stream could be affected by heavy metals, habitat, or a combination of the metals and habitat). Binns and Eiserman (1979) screen potential HQI sites and eliminated sites with large human-caused problems (e.g., channelized or heavily stocked with fish). As developed by Binns (1982), neither HQI Model I or Model II contained a water quality variable that would integrate heavy metals as a water quality variable in the CFR or the effects that such metals had on salmonid standing crop which could "mask" or "confound" other fish-fish food-habitat relationships.

If a habitat model, for whatever reason, explains the variation in the dependent variable (i.e., standing crop of trout), the model should be tested with data from streams that were not used in the original model development. Binns (1979) tested his Model I with data collected from 16 other reaches of Wyoming streams; 4 of the 16 reaches (i.e., 25 percent) were from streams used to build Model I. Model I explained only 59 percent of the variation in trout standing crop in the 16 test stream reaches. Binns (1979) converted Model I into Model II through the use of the data from all 36 streams, keeping the three "primary limiting" or individual rated variables from Model I, dropping the P-factor (i.e., product of seven variables including fish food abundance and fish food diversity), and creating the Food or F-factor (i.e., product of rated summer stream temperature, nitrate nitrogen, substrate, and water velocity) and the Shelter or S-factor (i.e., product of rated cover, eroding stream banks, and stream width). Thus, maximum summer stream temperature (i.e., Binns' X_3 variable) was present in Model II as an individual variable and as one of the four variables in the Food or F-factor even though it was one of two variables (i.e., the other being late summer stream flow) in the overall model that did not have a significant multiple correlation coefficient in their relationship with trout standing crop. Furthermore and across both Model I and II, all habitat variables, when rated from 0 to 4, were based on ranges found in selected Wyoming stream systems, which, when combined with other variables in the F and S-factors, could result in the entire factor being zero

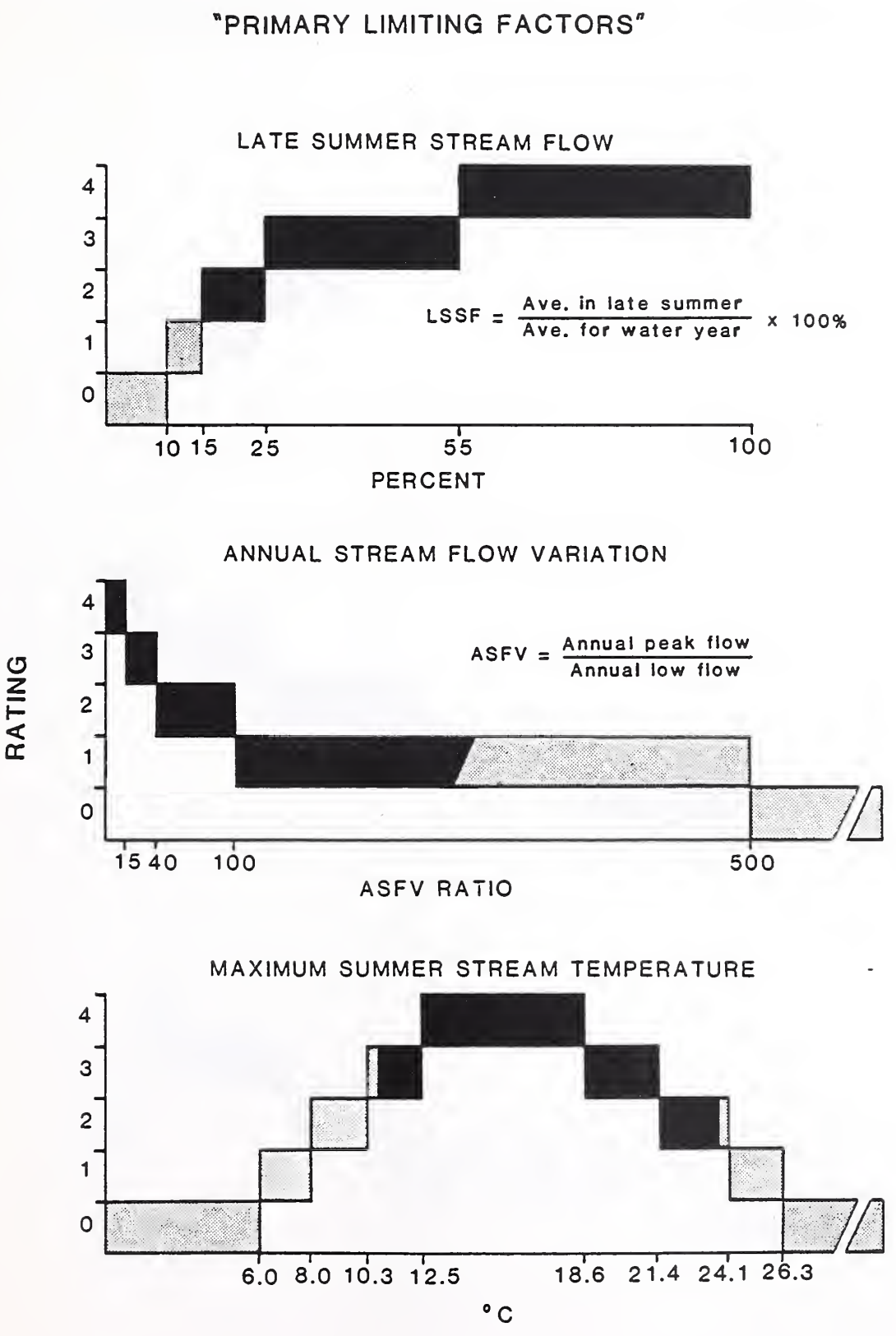

Figure 1. Distribution of ratings (i.e., 0 through 4) and ranges of variables per rating in Binns (1979a) Habitat Quality Index (HQI) Model II. Blackened areas of rating "blocks" were actual data ranges collected by Konopacky and Petrosky (1983) from 65 stream reaches in Idaho and Washington.

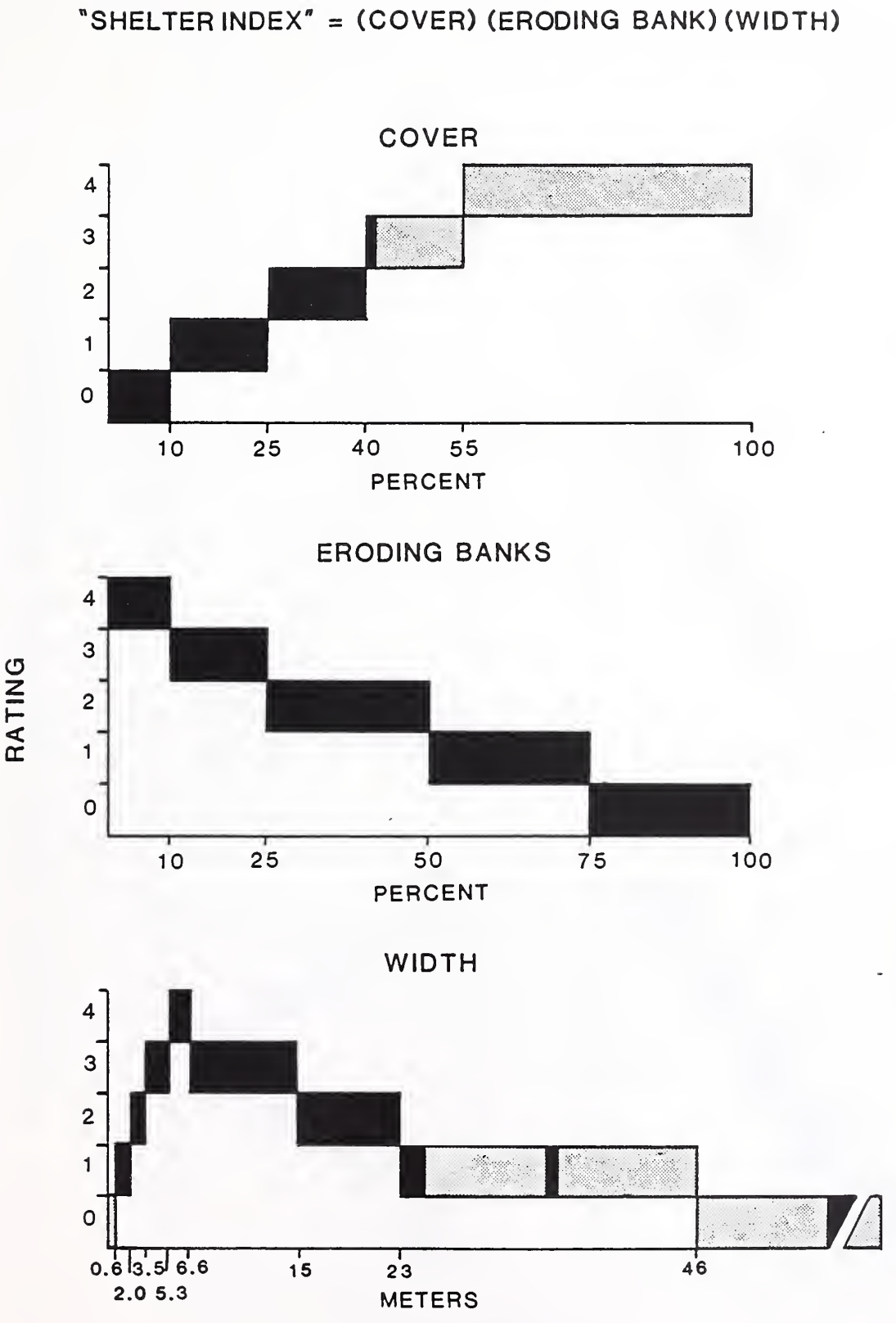

Figure 1. Continued.

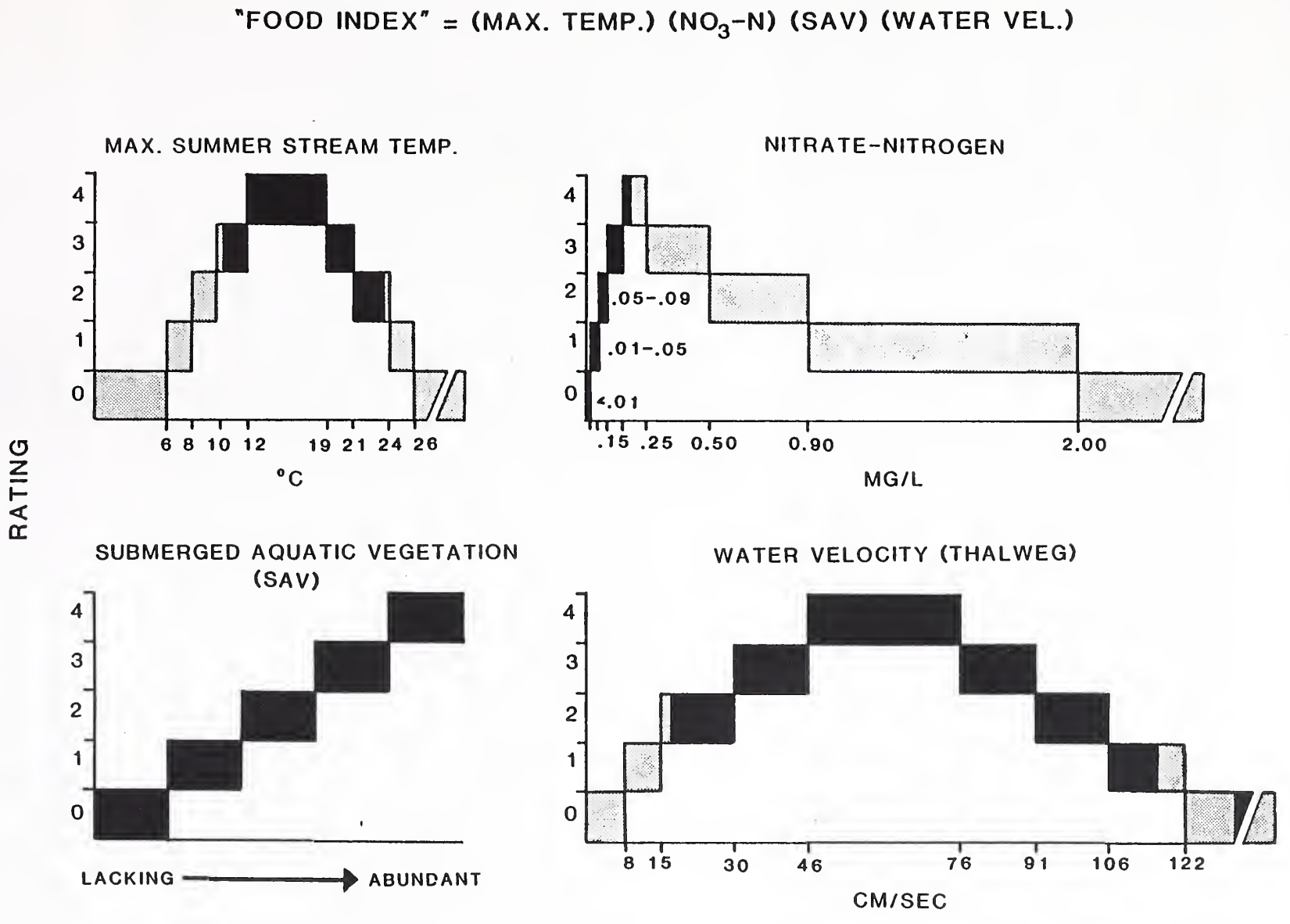

Figure 1. Continued.

if any one of the components was rated as zero (i.e., multiplication by zero). From a common sense approach, most "trout" streams logically have some food or shelter (versus zero) or they would not be trout streams.

Binns (1979) tested Model II with data from eight other stream reaches from Wyoming stream systems; 7 of the 8 reaches (i.e., 88 percent) were located in the same stream systems that were used to build Model II. Binns (1979, 1982; Binns and Eiserman 1979) never revealed, in any subsequent publication, how much variation in salmonid standing crop was explained in the eight stream reaches used to test Model II except to state that the results were better than Model I. Even though Binns (1979) showed that Model II explained 97 percent of the variation in actual standing crop in the original 36 stream reaches used to build the model, a review of the predicted and actual standing crop data generated by Model II shows that within individual stream basins (e.g., Little Snake River) predicted standing crops ranged from 48 to 257 percent of the actual standing crop. Thus, across all stream reaches and systems in Wyoming, Model II provided a "ballpark" estimate for all reaches. If a particular stream system was examined, however, predicted standing crops fluctuated above and below actual estimates for unexplained reasons.

Why the HQI Model should not be used in the CFR.

Reiser (1995) elected to use the HQI Model and other models or techniques (e.g., Trout Rating or TCR [Wesche 1980]) to predict trout standing crop and/or rate/measure habitat components such as cover, respectively, in the CFR. Reiser used HQI with the knowledge that the model did not contain a water quality variable that would measure or define the effects of heavy metals, in the CFR, on fish or fish food populations. In addition, Reiser used the HQI regardless of accounts in the published and unpublished literature that showed the HQI primarily worked in those stream basins in Wyoming where the model was built and "tested" and given the published (Binns 1979; 1982) ranges of fluctuations and lack of accuracy/precision in within-basin applications. In a limited defense of his use of the HQI Model in the CFR, Reiser (1995, p. D3-16) states that *"(t)he HQI model has been used for predicting trout standing crops in Wyoming streams and has been applied to other Rocky Mountain regions, including Montana."* Relative to this statement, Reiser failed to provide any references for the reader to corroborate or justify his use of the HQI model in the CFR or the success of the HQI model in Wyoming or other Rocky Mountain stream systems.

In addition to the HQI Model generally failing in within-basins situations in Wyoming (Binns 1979; 1982), the published and unpublished literature contains reports of the failure of the model in stream/river systems in Montana and Idaho as well as in other geographic regions

(e.g., Ontario, Canada). White et al. (1983) used the HQI Model II to predict trout standing crop in 16 urban and 14 non-urban reaches of four streams in and near Bozeman and Livingston, Montana. Across all 30 reaches, the HQI Model explained 5 percent of the variation in standing crop. In general, most HQI-predicted standing crop values were greater to much greater than the measured values in the four stream systems. Across all four systems, only 8 of the 30 (i.e., 27 percent) predicted standing crop estimates were less than the measured values. More importantly, in within-basin applications, all predicted values were greater than the measured values in Mathew Bird Creek (i.e., range of 101 to 775 percent). In contrast, all predicted values were less than the measured values in Fleshman Creek (i.e., range of 57 to 68 percent), which suggests a systematic flaw in the model or data collection methods. Lastly, only 4 of the 30 predicted values were within 20 percent of the measured values in the streams. Based on the performance of the model, White et al. (1983) concluded that the HQI model was not applicable to the trout/habitat relationships in the Montana study streams or some deficiency was present in the method of making habitat/fish measurements. Another conclusion was that the subjective nature of making prescribed measurements was less than desirable but that some of the subjectiveness was possibly offset by the rating of the habitat measurements with a commensurate loss of information. The results of the 1983 study do not provide any evidence that the model would or could perform to any level of acceptance and would, therefore, be appropriate for use in the CFR without substantial modifications and subsequent testing.

Konopacky and Petrosky (1983) attempted to use the HQI model to predict trout standing crop in 28 reaches of the Clearwater River system of Idaho (i.e., just west of Missoula and the CFR). The HQI model explained only 0.06 percent of the variation in trout standing crop in the study reaches. The authors indicated that the HQI model failed because the ranges of the variables in the Clearwater River system were different from the ranges observed in Wyoming and used to build the original model. Subsequently, the subjective rating system failed to detect real differences between or among habitat components and, thus, "hid" information (Figure 1). Even though the Konopacky/Petrosky study was not technically in the Rocky Mountains, it was close to the CFR. Inability of the model to predict standing crop would not promote the use of the HQI model in the CFR.

Bowlby and Roff (1986) also tested the ability of the HQI model to predict trout standing crop in 30 stream reaches located in three river systems in Ontario, Canada. The HQI Model II explained only 9 percent of the variation in trout standing crop in their study reaches. They found that of the variables in Model II, late summer stream flow, annual stream flow variation, and maximum summer stream temperature were significantly correlated with trout biomass; in contrast, Binns and Eiserman (1979) reported that, of the 11 variables in Model II, late summer stream flow and maximum summer stream temperature were the only variables not significantly

correlated with trout biomass in the Wyoming streams. From these differences, they concluded that "(c)learly different factors limit trout biomass in Wyoming than in southern Ontario." As points of discussion, they emphasized caution in the use of any empirical relationship, suggested any model should be tested with representative data from the proposed location of use, and questioned the subjective nature of using the rating system for continuous data in the model. Reiser (1995), although not suggesting that the results of a Canadian study supported the use of the HQI model in the CFR, could have heeded the cautionary points made by the authors relative to a priori model testing and the questionable rating system for measured variables.

Scarnecchia and Bergersen (1987) used the HQI Model to predict standing crop of trout in reaches of 10 northern Colorado streams in 1979 and 1980. Four of the sites, although in Colorado, were in the same river systems (i.e., Platte and Laramie rivers) used by Binns and Eiserman (1979) in Wyoming to develop the HQI model. The HQI model explained 44 percent of the variation in standing crop of the stream reaches in 1979 but only 16 percent in the same stream reaches in 1980. Predicted standing crop values ranged from 26 to 605 percent of measured values in 1979 and 4 to 354 percent of measured values in 1980. In 9 of the 10 streams between years, predicted values were consistently higher (e.g., Davis Creek, 605 percent in 1979 and 346 percent in 1980) or consistently lower (e.g., Nunn Creek, 54 percent in 1979 and 29 percent in 1980), which suggested a systematic problem in the overall model. The authors concluded that the limited ability of the HQI model to predict trout standing crops was caused by: 1) a lack of exact measurements according to the Binns and Eiserman (1979) methods; 2) the inability of the HQI Model II to account for subtleties in habitat; and 3) differences between their study streams and the streams used to build the HQI model. Again, without knowing which studies Reiser (1995) used to support the contention that the HQI Model was preferred for use in the CFR, the Colorado (i.e., Rocky Mountain) study certainly does not provide any evidence, especially in the same streams over two years, that the model would or could work in the CFR at some scientifically acceptable level.

Fausch et al. (1988) critically reviewed nearly 100 models, including the HQI Model II, that investigators had previously used to predict standing crops of stream fishes from habitat variables. They stated that the HQI model structure was complicated because of the variable rating process and the multiplication of groups of rated variables into indices (i.e., F-factor and S-factor). They also observed that the probability of prediction error was significant, relative to model accuracy, because of the existence of one large datum (i.e., 634 kg/ha or 565 pounds/acre) that placed a disproportional amount of control or leverage over the overall regression.

In review, Reiser (1995) used the HQI in the CFR even though the model did not include a variable that would measure the range of heavy metals in the system. He could have stated an assumption (i.e., heavy metals present in the CFR have no effect on fish or fish food) or created a variable in the HQI model that would have measured the levels of metals present and addressed the varied effects on fish and fish food populations. In addition, Reiser's (1995) use of past studies in Montana and other Rocky Mountain regions as a reason for the use of the HQI model in the CFR is not supported by the published and unpublished literature that I reviewed. Indeed, all HQI studies, regardless of their location, had extremely inaccurate predictions of the standing crop of trout, within specific stream basins, and most had very poor results across all streams. All authors and reviewers cautioned the use of the model and most (e.g., Bowlby and Roff 1986) suggested that testing was a prerequisite for use. In other words, Reiser (1995) should not have used the HQI model in the CFR unless: 1) he recognized the presence and confounding effects of heavy metals in the CFR via a stated assumption or a customization of the HQI model; 2) his non-referenced studies provided more-than-adequate evidence to rebut the above-cited studies; and 3) he provided the necessary prerequisite information for a priori testing of the model in the CFR relative to acceptable levels of accuracy and precision in predicted or measured levels of the standing crop of trout in the various reaches of the river system.

Was the HQI Model used correctly by ARCO in the CFR?

Regardless of the unsupported and inappropriate nature of the use of the HQI model to measure habitat and predict trout standing crops in various reaches of the CFR, an examination of the reported HQI values, actual field data, and calculations (Table 1) suggests that the model was incorrectly used and input data was incorrectly or inconsistently collected or ignored by Reiser (1995). Four areas will be presented to support the above statement: 1) reported HQI values were not collected correctly; 2) existing potential HQI values were ignored; 3) input variables for HQI Models I and II were both used in Model II based on available data collected by ARCO; and 4) measurements of some HQI variables (e.g., cover) collected by ARCO investigators vary greatly from the reported HQI values.

HQI values reported by Reiser (1995, p. D5-3) are identical across all 27 sites for four variables: late summer stream flow (X_1), annual stream flow variation (X_2), nitrate nitrogen (X_4), and the "food" variable (X_9)(Table 1). Regardless of the ratings assigned, the actual ranges of each variable or factor will not generate a constant rated value over the length of the CFR study

Table 1. Duplication of Reiser (1995, p. D5-3). Reiser title: Table 5.1-1. Rated values at Clark Fork River sites for all variables used in the Habitat Quality Index (Binns 1).

Site	CPF X_1	ASVF X_2	TEMP X_3	N-NO_3 X_4	COVER X_7	BANKS X_8	FOOD* X_9	VEL X_{10}	WIDTH X_{11}	HQI score (lbs/acres)
2-1.1	3	3	3	2	1	3	4	2	3	125
2-1.2	3	3	3	2	1	3	4	3	3	162
2-1.3	3	3	3	2	1	3	4	3	3	162
2-2.1	3	3	0	2	1	2	4	4	3	1
2-2.2	3	3	0	2	0	4	4	3	2	0
2-2.3	3	3	0	2	1	3	4	3	2	1
3-1.1	3	3	0	2	0	4	4	4	1	0
3-1.2	3	3	0	2	0	4	4	4	1	0
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3-2.1	3	3	0	2	0	2	4	4	1	0
3-2.2	3	3	0	2	0	3	4	4	2	0
3-2.3	3	3	0	2	0	2	4	4	2	0
4-1.1	3	3	1	2	1	4	4	3	1	30
4-1.2	3	3	1	2	1	3	4	4	1	34
4-1.3	3	3	1	2	0	2	4	4	1	27
4-2.1	3	3	1	2	0	2	4	4	1	27
4-2.2	3	3	1	2	0	3	4	4	1	27
4-2.3	3	3	1	2	0	2	4	3	2	22
5-1.1	3	3	1	2	1	3	4	3	1	29
5-1.2	3	3	1	2	1	4	4	4	1	36
5-1.3	3	3	1	2	1	4	4	3	1	30
5-2.1	3	3	1	2	1	4	4	4	1	36
5-2.2	3	3	1	2	1	3	4	3	1	29
5-2.3	3	3	1	2	1	2	4	4	1	33
6-1.1	3	3	2	2	2	4	4	3	1	86
6-1.2	3	3	2	2	2	4	4	3	1	86
6-1.3	3	3	2	2	2	4	4	3	0	57

* Reiser (1995) presents variable X_9 as the Food or F-factor while Binns (1979a) presented variable X_9 as the substrate variable.

sites used by Reiser (1995). None of the four variables, with a constant value over all 27 sites makes sense, given the variable ranges in stream flow, stream temperature, stream gradient, water chemistry, and aquatic vegetation (i.e., X_9 variable in HQI Model II). Using late summer stream flow as an example, Reiser (1995, p. C-22) states that *"irrigation diversions and dewatering have their greatest impacts in the reach of river above the Little Blackfoot River, and in particular, sections of river directly below irrigation diversions"* and *"the entire streambed below the diversion and extending for 1500 ft downstream was essentially dewatered"*. Such statements imply that other areas of the CFR were not dewatered and are in direct contrast to the photograph of the Clark Fork River near Bearmouth (Reiser 1995, p. C-3) that shows large amounts of water in the channel. Reiser provides the proof of such observed or measured variation in flow but yet assigned the second highest HQI rating to all of his 27 study sites (i.e., a "3" or moderate late summer stream flow; may occasionally limit trout numbers [Binns 1982]).

As a second example, Reiser identified the X_9 variable in HQI Model II as a "food" variable and redefined the variable (EA Engineering 1991) only as various ranges of macroinvertebrate densities. In contrast, Binns and Eiserman (1979) and Binns (1982) used the X_9 label for the "substrate" variable while their Food or F-factor was the product of ratings for maximum summer stream temperature, nitrate nitrogen, substrate, and water velocity. In their HQI Model II, Binns and Eiserman (1979) relied on submerged aquatic vegetation (SAV) as the primary factor in the substrate or X_9 variable and did not collect actual macroinvertebrate densities or depend on densities for the determination of a rating. They did, however, use macroinvertebrate densities and macroinvertebrate diversity as two components of the four-part P-factor in their HQI Model I. In a departure from HQI Model II directions, Reiser (1995) failed to measure SAV and only used macroinvertebrate densities as his information base for ratings in his "food" or X_9 variable (EA Engineering 1991). Thus, because Reiser (1995) did not make correct measurements of habitat variables, his reported HQI values are wrong, and the subsequent predicted standing crop values of trout are incorrect.

I also found that Reiser (1995, p. D5-3) used the same HQI values for nitrate nitrogen across all 27 sites (Table 1). Reiser (1995, p. D2-65) reported that nitrate nitrogen data were *"not available"* even though EA Engineering (i.e., Reiser's employer) collected water samples from all 27 sites for nitrate nitrogen analysis in 1988 and 1989 (EA Engineering 1991). Such data were also available in a number of forms and from a number of other investigators (e.g., Ingman and Kerr 1990). The subjective assignment of a "2-rating" to all sites would have a buffering effect on the F-factor (i.e., nitrate nitrogen is one of four rated variables multiplied together) and disproportionately weight the influence of other non-zero components [e.g., maximum summer stream temperature]). A brief review of the Ingman and Kerr continuous data for nitrate nitrogen at or near the 27 ARCO sites produced HQI-rated values of 0 for all

sites except the six 4-1 and 4-2 sites that were rated as 1. Because nitrate nitrogen and maximum summer stream temperature are both part of the F-factor index, a zero rating for either would reduce the F-factor to zero (i.e., multiplication by zero). Based on the above nitrate nitrogen rated values and the rated values for maximum summer stream temperature, 21 of the 27 sites would have a HQI value of zero in the F-factor; only the six 4-1 and 4-2 sites would have a non-zero value. Thus, because Reiser (1995) failed to use existing data for the nitrate nitrogen variable in his HQI model in deference to a subjectively-assigned constant level, his reported HQI values are in error and the subsequent predicted standing crop values of trout are incorrect.

Based on my knowledge of the HQI models, I concluded that Reiser (1995) mixed input variables for HQI Models I and II to generate fish standing crop estimates from Model II because of a failure to collect required information. Binns (1982) modified input variables and data from Model I to create Model II. Their X_9 or substrate variable was created because the collection, identification, and analysis of macroinvertebrate samples was considered too time-consuming and expensive. As such, their new substrate variable primarily depended on the amount of SAV (i.e., submerged aquatic vegetation) present in a study reach. Because other ARCO investigators had collected macroinvertebrate samples in other studies, Reiser (1995) elected to use the existing data rather than measure SAV. As mentioned above, macroinvertebrate densities and diversity were both components of the variable in HQI Model I. If Reiser (1995) wanted to substitute macroinvertebrate density from Model I for the SAV measurement in Model II, the WGFD (Pers. comm., September 21, 1995) requires that macroinvertebrate diversity also be used in the calculation and rating procedures. Even though Reiser (1995) assigned densities a constant and highest rating across all 27 sites, EA Engineering (1991) stated that *"diversity of the macroinvertebrate communities sampled was not very high which was an indicator that the food base for fish may not be very stable."* Similar to the variance in macroinvertebrate diversity, SAV varies throughout the CFR. Reiser (1995) arbitrarily mixed data inputs from HQI Models I and II by using only macroinvertebrate densities as input for Binn's (1982) substrate variable. He also chose not to use existing and required diversity data that would, in conjunction with the density data, have modified his constant ratings over the study sites in the CFR. A substitution of only macroinvertebrate density from HQI Model I cannot be substituted for a measurement and rating of SAV in HQI Model II. Thus, because Reiser (1995) used partial input data for a variable for HQI Model I as a substitute for a non-measured variable in HQI Model II, the reported HQI values are wrong and the subsequent predicted standing crop values of trout are incorrect.

The HQI values for cover, as reported by Reiser (1995, p. D5-3)(Table 1), are inconsistent with values presented later by Reiser (1995, p. D5-7). As reported in Table 5.1-1, cover ranged from 0 to 2. Cover in the 2-1 and 2-2 sites are generally rated as a 1; cover in the 3-2 and 4-2 sites were all rated a 0; cover in the 6-1 sites were all rated a 2 (i.e., a 1 connotes less cover than a 2). In contrast, in Reiser (1995, p. D5-7), through use of the TCR method of cover rating and regardless of measurement scale, 2-1 and 2-2 sites have 2 to 3 times more cover than the 6-1 sites. Similarly, the highest TCR cover rating was assigned to Site 4-2.2, which was assigned a zero, or the lowest, rating under the HQI rating format. TCR ratings for some 3-2 sites were eight times higher than some 4-2 sites although both sets of sites all received zero ratings within the HQI process. Some information is obviously hidden by the rating of variables within the HQI model process. Such major differences in the measurement of the same variable by two different methods should not, however, produce the best and worst rating or score for the same study site. Thus, because Reiser (1995) inconsistently measured key habitat variables in the HQI or TCR techniques, his reported HQI/TCR values for cover are wrong, and the subsequent predicted standing crop values of trout (i.e., within HQI) or cover (i.e., within TCR) are incorrect as stated in the ARCO report.

In review, Reiser (1995) incorrectly collected or rated data, failed to use existing data, arbitrarily elected to modify data inputs and variables in the HQI Model II, and inconsistently measured habitat based on the results presented in his report and supporting documents (i.e., EA Engineering 1991). As such and regardless of the inappropriateness of using the HQI model in the CFR, all HQI values presented by Reiser (1995), either the rated variables or the predicted standing crops cannot and should not be considered correct or used at any level of decision-making.

What other methods, other than the HQI-predicted values, could be used to estimate the standing crop of trout in the CFR?

Given the above findings from other HQI-studies and the data/measurement problems in the ARCO HQI effort, Reiser (1995) could or should have used other classification methods or approaches to estimate the standing crop of trout in the CFR. Reiser could have used a number of sites in a number of reference streams, similar to the State of Montana's approach, to estimate the amount of trout standing crop in the CFR. Even if discrepancies occurred as a result of different people making different measurements in different streams, the overall similar nature of the approach would probably result in less than large disagreements in final results between ARCO and the State of Montana.

Conclusion

ARCO/Reiser (1995) should not have used the HQI model to predict standing crops of trout in the CFR based on the results of earlier HQI studies in streams in Montana, Colorado, Wyoming, Idaho, and Ontario, Canada. Regardless of the findings of other studies, if ARCO insisted that the HQI model was to be used, Reiser needed to meet HQI model assumptions, the HQI model needed to be tested, and measurements of habitat variables needed to be recognized as available or measured correctly for use in subsequent calculations. If, on the other hand, the rejections of the HQI model predictions in past studies were recognized by ARCO, other stream classification approaches were available for use by ARCO to predict standing crops of fish, without mine waste, in the CFR. Reiser (1995) criticized the State of Montana approach for the estimation of trout biomass in the CFR as being untested, invalid, and based on failed assumptions. The State used a control:treatment stream format, performed partial validations, and met general assumptions of the utilized approach. In contrast, Reiser failed to test the HQI model in the CFR, did not conduct any validation efforts, and failed to meet the general assumptions of the overall model (e.g., use of real or complete data for nitrate nitrogen and macroinvertebrates, respectively, versus subjective assignment of a constant level across all study sites). The State of Montana's approach for the estimation of the standing crop of trout in the CFR is much more defensible, correct, precise, and accurate than any level of HQI modeling in the CFR.

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